February 15, 2008

TO: Mill Creek Sub-Committee
FROM: Dave Amman, Hydrologist, DNRC Water Measurement Program
RE: Mill Creek Water Measurement History, Data Review, Monitoring Plan

I was asked to explain past involvement of the Water Measurement Program in Mill Creek, perform a search and review of existing data for the watershed, and provide a monitoring plan update for Mill Creek. Hopefully you will find the following information useful.

DNRC Water Measurement Program Involvement in the Mill Creek Basin

In 1991 the DNRC Water Measurement Program held public scoping meetings to gauge interest for the designation of Mill Creek as a chronically dewatered watercourse, and therefore inclusion into the program. As a result of those meetings, a report was prepared and finalized in 1993.

The designation of Mill Creek as "chronically dewatered" required that measuring devices be placed on all irrigation diversions from the creek, and that records be maintained and mailed to the DNRC each season. Almost all diversions were outfitted with measuring devices, and overall compliance was good for a few years beginning in about 1998.

The Water Measurement Program sent postcard "reminders" to water users several times, urging them to maintain the measuring devices and to keep good records for submittal at the end of the irrigation season. Also, in February 1998, a public meeting was held for the Mill Creek water users and interested parties. Water leasing was one of the main topics at the meeting.

The meeting generated good discussions about water use in the basin and gave the water users lead time to start thinking about the impending summer season.

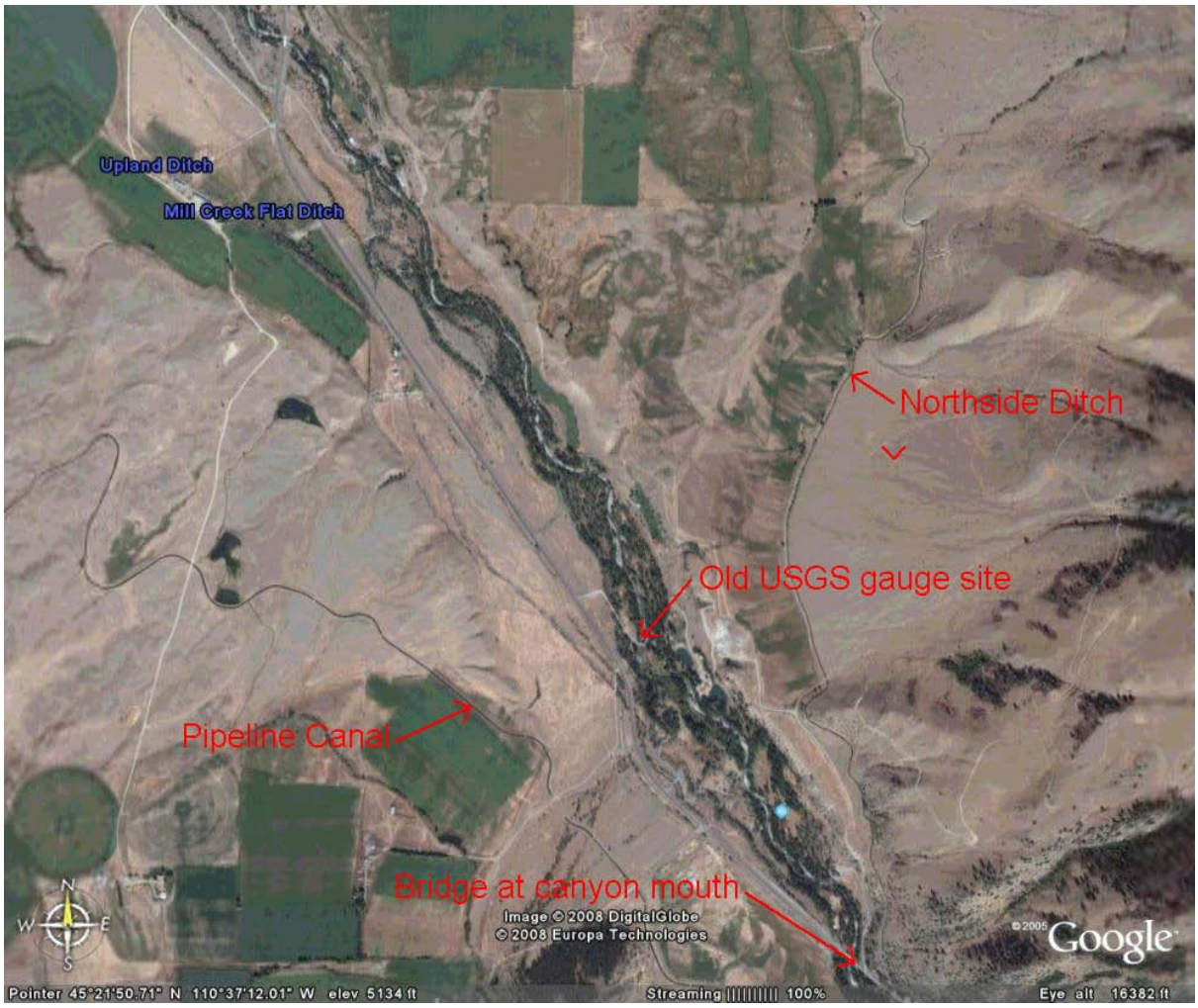
In late summer of 1999, most or all of Montana began to slip into the drought cycle that is currently gripping the state. As a result, the Water Measurement Program (consisting of one employee) and related resources were, and still are, stretched thin. The Program then had to reprioritize projects and work areas, with most efforts concentrated on larger basins.

In its' absence from the Mill Creek area, the Program has developed water measurement programs and had great success in the Musselshell, Big Hole, Georgetown Lake/Flint Creek, and Jefferson River basins and on several of their principal tributaries. With renewed interest in Mill Creek, the Water Measurement Program is again able to apply some of its' limited resources to the area in hopes of solving water shortages and conflicts between competing uses.

Existing Mill Creek and Yellowstone River Data

At this time, the only historic gauge data for Mill Creek are from the USGS gauge number 6192000. These data run from March, 1951 through September, 1956. Of course, these data far precede the construction and implementation of the pipeline and diversion above this gauge site.

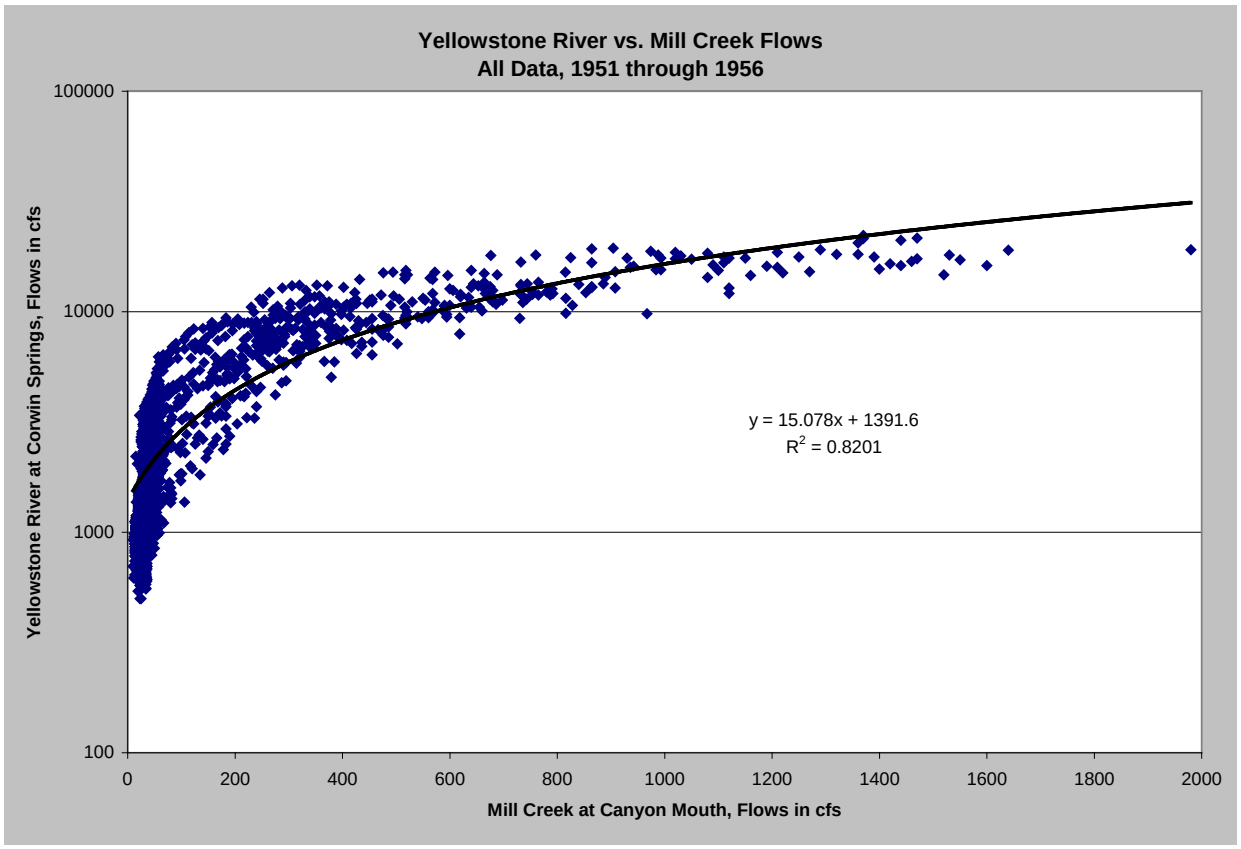
The following aerial photo shows the location of the discontinued gauge site on Mill Creek, as well as some of the principal ditches in the area.

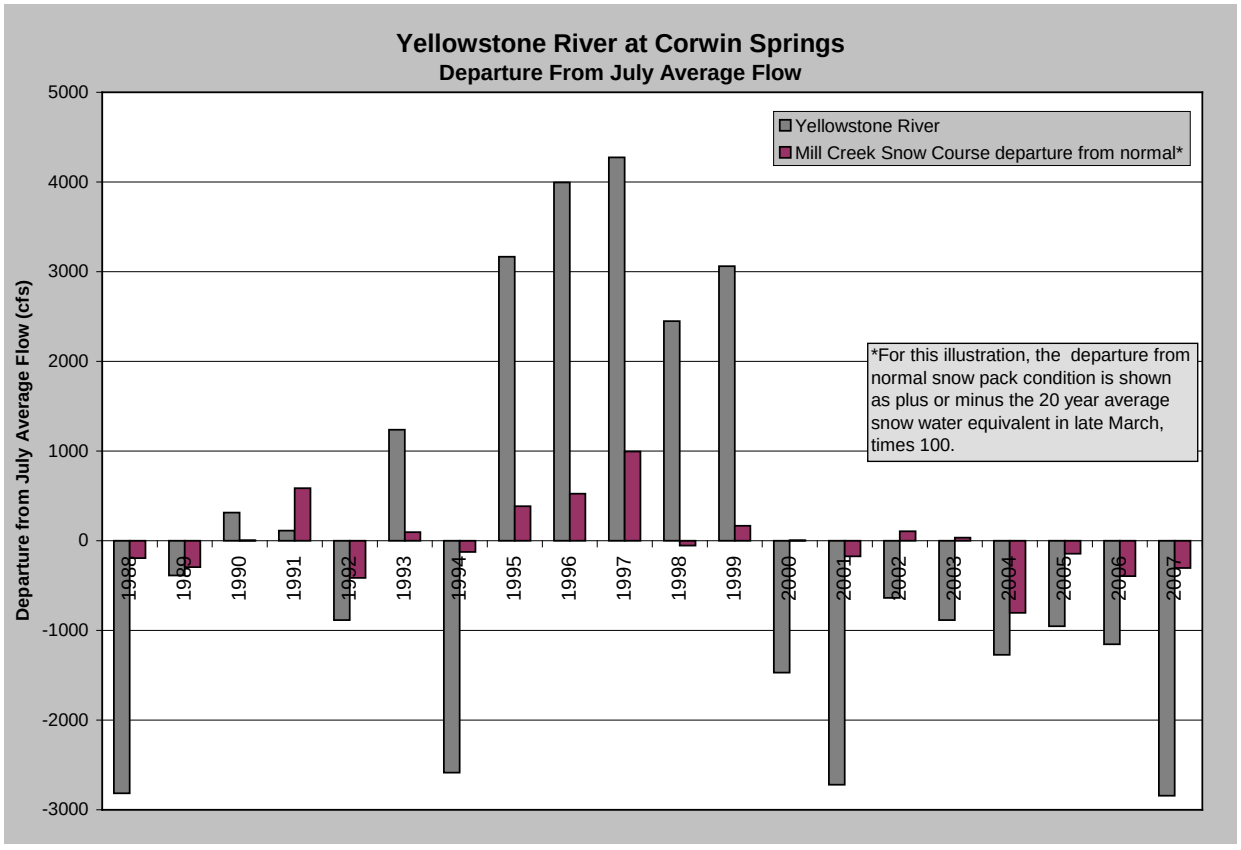


We can relate the old 1950's Mill Creek data to the 1950's data of the long-term USGS gauge, Yellowstone River at Corwin Springs. This gives us some idea of current flows on Mill Creek at the old USGS gauging site below the canyon mouth, even though it is not statistically a very powerful relationship with an r-squared of 0.82.

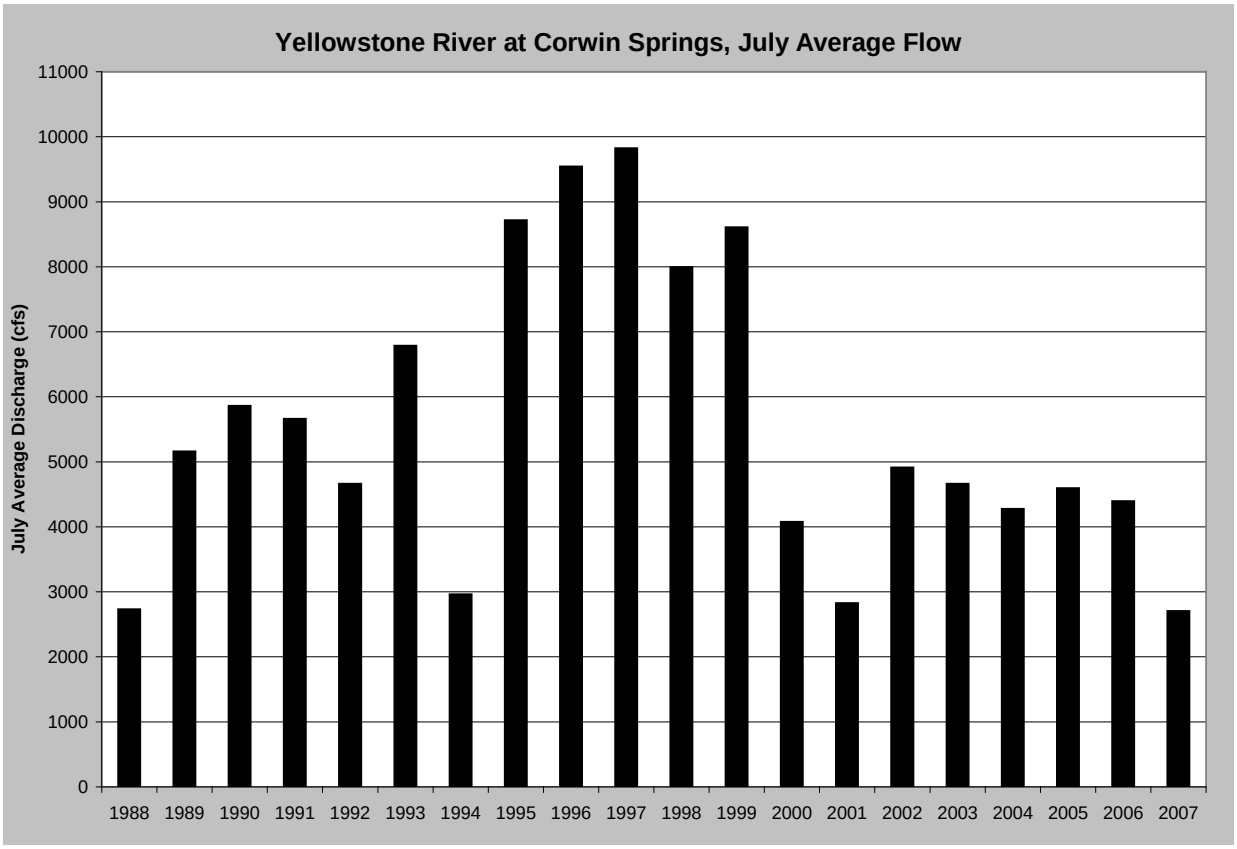
The upper graph on the following page shows the relationship of average daily flows at Mill Creek correlated to flows on the Yellowstone at Corwin Springs. This loose relationship emphasizes the need for new gauging of the present hydrologic situation.

We can also relate snow pack figures at the Mill Creek Basin to Yellowstone River discharge at Corwin Springs. The relationship tells us that if the snow pack measured in the Mill Creek Basin is low, then July flows on the Yellowstone will also be low. New gauging in Mill Creek will allow us to better correlate snow pack measurements to annual or monthly yields quite accurately. The lower graph on the following page illustrates this relationship.

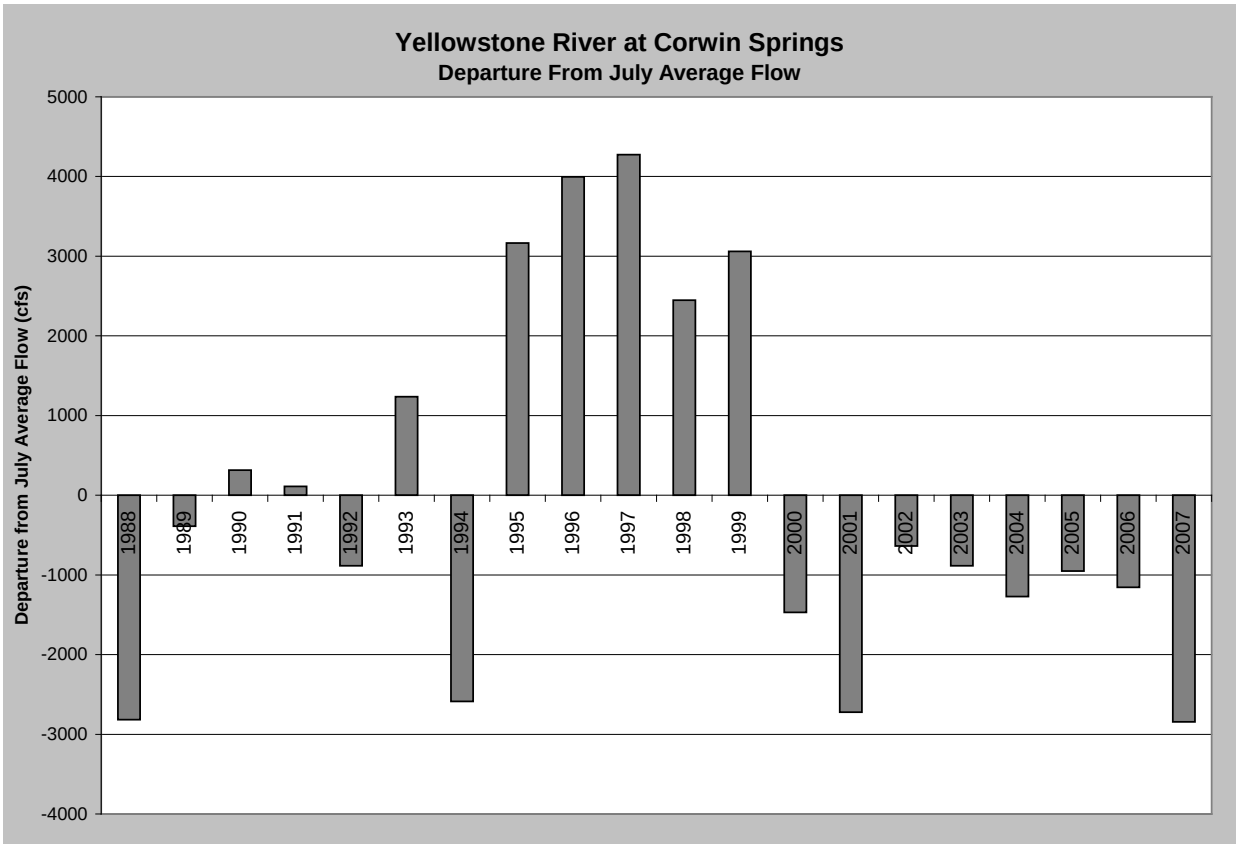

Yellowstone River vs. Mill Creek Flows
All Data, 1951 through 1956
Yellowstone River at Corwin Springs, Flows in cfs
100000
10000
1000
100
y = 15.078x + 1391.6
R2 = 0.8201
0
200
400
600
800
1000
1200
1400
1600
1800
2000
Mill Creek at Canyon Mouth, Flows in cfs


Yellowstone River at Corwin Springs
Departure From July Average Flow
Departure from July Average Flow (cfs)
5000
4000
3000
2000
1000
0
-1000
-2000
-3000
Yellowstone River
Mill Creek Snow Course departure from normal*
*For this illustration, the departure from normal snow pack condition is shown as plus or minus the 20 year average snow water equivalent in late March, times 100.
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007

The Yellowstone River gauge at Corwin Springs has operated for over 100 years. For our purposes, it is useful to look at the last 20 years of data, which show more current trends in the local hydrology. The following graph shows the average daily flow of the Yellowstone River for July, since 1988. Note the relatively lower flows since the year 2000.



Another way of looking at these trends is by examining the departure of the flows from the normal or average July flows. The following graph shows by year, the departure from normal July flows. Positive departure means that during that given year, average July flows were above the normal. Negative departure means that during that year, the July flow was below normal. Note the departure of July flows from normal since the year 2000. Also note that 1997 was the record snow pack year for most of Montana. In 1997, the July average flow was more than 4000 cfs above the normal.



Summary of Existing Data

Although there are 6 years of stream flow data for Mill Creek, those data are from the 1950's before the pipeline project was constructed. There are also snow pack figures for the Mill Creek Basin beginning in the 1960's and these are still collected by the NRCS. There is a long-term USGS gauge for the Yellowstone River at Corwin Springs and it is useful for comparing Mill Creek flows during the 1950's to Yellowstone River flows during the 1950's.

However, there otherwise is little or no overlap between these data sources, and to the best of my knowledge there are almost no current Mill Creek flow data that inform us of the flow characteristics at the desired locations.

To collect these meaningful data, we must install continuous stage recorders on Mill Creek. This information will give us an understanding of the current status of the hydrologic situation in the Mill Creek Basin.

Mill Creek Monitoring Plan Update, February 14, 2008

The proposed monitoring plan presented last October (see attached) listed the following monitoring sites in the Mill Creek basin:

Station 1: WLR	**Mill Creek at East River Road**
Station 2: RS	Paradise Canal at Mill Creek siphon
Station 3: RS or WLR	**Mill Creek above Allen-Sexton Ditch**
Station 4: RS	Allen-Sexton Ditch (existing Parshall Flume)
Station 5: WLR	**Mill Creek at First Bridge of Mill Creek Rd (sec 29, T6S R9E)**
Station 6: RS	Pipeline Canal
Station 7: RS	Mill Creek at Second Bridge of Mill Creek Rd (sec 33, T6S R9E)
Station 8: WLR	**Mill Creek above Pipeline Intake (sec 2, T7S R9E)**

Continuous water level recorders (TruTrack) would be installed at stations designated "WLR", while rated staff gauges would be installed at the other stations, designated "RS". Some of these stations are more important than others, and the priority sites are bold, underlined. I have ordered 3 continuous WLR's for this project, should it go forward, and I may have a fourth at my disposal. The sites monitored with the use of rated staff gauges (RS) would provide points of instantaneous observation between the WLR sites. While they may not seem critical, they would greatly assist in the overall gauging/monitoring/data collection effort and understanding of the Mill Creek system.

While high flows are interesting and useful data, the emphasis of this project is low flow monitoring. For that reason, gauge installation should proceed after peak flows, likely in late June or early July. It is fundamental to the project to locate these gauges where they can continuously monitor the lowest occurring flows. It is difficult to insure that they will be located correctly during times of high flow. These gauges can gather the useful data for any number of seasons that we deem appropriate. I would suggest at least three or four years of data collection.

Approximately 10 years ago, I installed or assisted in the installation of water measuring devices on several of the Mill Creek irrigation diversions. I am guessing that most of those devices (mainly rated staff gauges) are now non-functioning and will need replacement if the diversions are to be monitored. Some exceptions are the Allen-Sexton ditch which has (had?) a Montana flume installed; the Northside Ditch which had a concrete Montana flume installed; and the Pipeline Ditch which had a Parshall flume installed. If diversions are to be measured indefinitely, standard measuring flumes should be installed.

Water measurement is fundamental to water management, and it is important to measure the diversions. However, the purpose of measuring the diversions is not so much for enforcement purposes, but for water accounting within the basin (basin modeling). Basically, we need to know where the water goes so that we can explore solutions to improve flows at the mouth of the creek.

Proposed Flow Monitoring Plan for Mill Creek

October 4, 2007

The purpose of installing a gaging network on Mill Creek will be to gather information about the flow characteristics through both time and distance. In its' lower reaches, Mill Creek dries up almost entirely in late summer, but there may be ways to augment flows in these reaches.

In order to explore possible solutions to this problem, we need detailed information about the timing of the stream flows and about the locations and characteristics of the larger diversions along the stream. From points relatively higher up on the creek, several of the canals divert water out of the Mill Creek watershed. The portion of that diverted water that may have otherwise made it to the mouth of Mill Creek, comes back now as either groundwater or surface water directly to the Yellowstone River.

I offer the following gage locations as a first suggestion. Continuous water level recorders (TruTrack) would be installed at stations designated "WLR", while rated staff gauges would be installed at the other stations, designated "RS". To my knowledge, there is an existing Montana Flume on the Allen-Sexton Ditch, and a flume or other measuring device on the Pipeline Canal.

Station 1: WLR	Mill Creek at East River Road
Station 2: RS	Paradise Canal at Mill Creek siphon
Station 3: RS or WLR	Mill Creek above Allen-Sexton Ditch
Station 4: RS	Allen-Sexton Ditch (existing Parshall Flume)
Station 5: WLR	Mill Creek at First Bridge of Mill Creek Rd (sec 29, T6S R9E)
Station 6: RS	Pipeline Canal
Station 7: RS	Mill Creek at Second Bridge of Mill Creek Rd (sec 33, T6S R9E)
Station 8: WLR	Mill Creek above Pipeline Intake (sec 2, T7S R9E)

This distribution of observation stations would give us information about the flows of Mill Creek as it enters Paradise Valley and at strategic points downstream toward the mouth of the creek. Fish, Wildlife & Parks has previously installed temporary gages at the lower and upper bridges for flow monitoring, and their data will also be useful.

At this time, the listed locations are theoretical as creek access must first be approved, and permission from the canal operators must be gained in order to measure their diversions. In the past, access has been allowed by operators of the Allen-Sexton ditch and other landowners along the creek.

The equipment cost of this proposed gauging network would be approximately $1500, and the bulk of the technical work would be taken on by the DNRC Water Measurement Program and FWP personnel. It is possible that we have enough water level recorders in our possession, otherwise the instruments would be ordered later this fall and installed after high water in late June 2008. Flow monitoring could continue for several years after installation of the network.

Flow Background

During the early 1950's the USGS operated a stream gaging station on Mill Creek. That station was located near the mouth of the canyon in section 33, T6S R9E and ran from March of 1951 through September of 1956. Although this is a short period of record, useful comparisons can be made between this Mill Creek gage and the USGS gage, Yellowstone River at Corwin Springs, which now has 101 years of record.

A brief comparison of hydrographs for 1951 through 1956 shows that the Yellowstone River at Corwin Springs experienced very near-normal late season (August & September) flows during 1951, and below-normal flows for 1952 through 1954. This suggests that normal late season flows for Mill Creek are represented by the 1951 hydrograph, which shows the flows being between 40 and 50 cfs at the mouth of the canyon.

The average monthly flows for August and September of 1951 were 70 cfs and 43 cfs, respectively. The lower flows during 1952 through 1954 are below 30 cfs and some are in the mid-teens. These figures give an idea of what may be considered historic normal, and below-normal late season flows at the mouth of the canyon.

More data exist and will be explored and analyzed more thoroughly this winter.

Setting

According to a report prepared by the DNRC Water Measurement Program in 1993, there are approximately 4,300 acres of lands irrigated by Mill Creek water. Approximately 75% of these lands are served by sprinkler irrigation. The vast majority of these parcels lie outside of the Mill Creek watershed, so any return flows go to the Yellowstone River, not back to Mill Creek.

Also according to the report, soil permeability is moderate to a depth of about 17 inches, and below that depth permeability is very rapid.

These factors all contribute to extremely low flows at the mouth of Mill Creek. The low flows are further exacerbated by the ongoing drought. Last year in April, the time of normal maximum snow pack accumulation, Mill Creek snow courses revealed snow water equivalent of only 67% of normal. Since 1998, only in 2006 and in 2003 have the April snow water equivalents been above normal, and then only slightly at 111% and 108% respectively.

Dave Amman, Hydrologist
Montana DNRC, 444-6648

Aerial View of the lower Mill Creek Basin. Also shown are proposed flow monitoring sites.